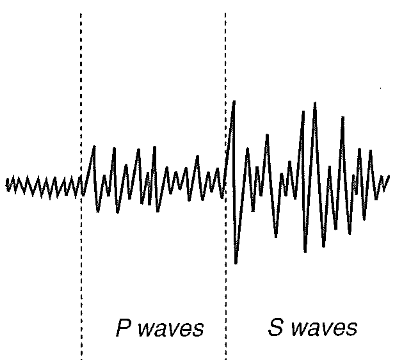
II Locating an Earthquake

OBJECTIVES

A Describe how a seismograph works.

B Discuss the relationship between the arrival time of the *P* and *S* waves at a seismograph station and the distance of the station from the earthquake epicenter.

C Explain how to locate an earthquake epicenter.



15.4 Seismic waves as they would look on a seismogram

15.5 Different kinds of seismographs record earthquakes by tracing earthquake waves.

Topic 5 Seismographs

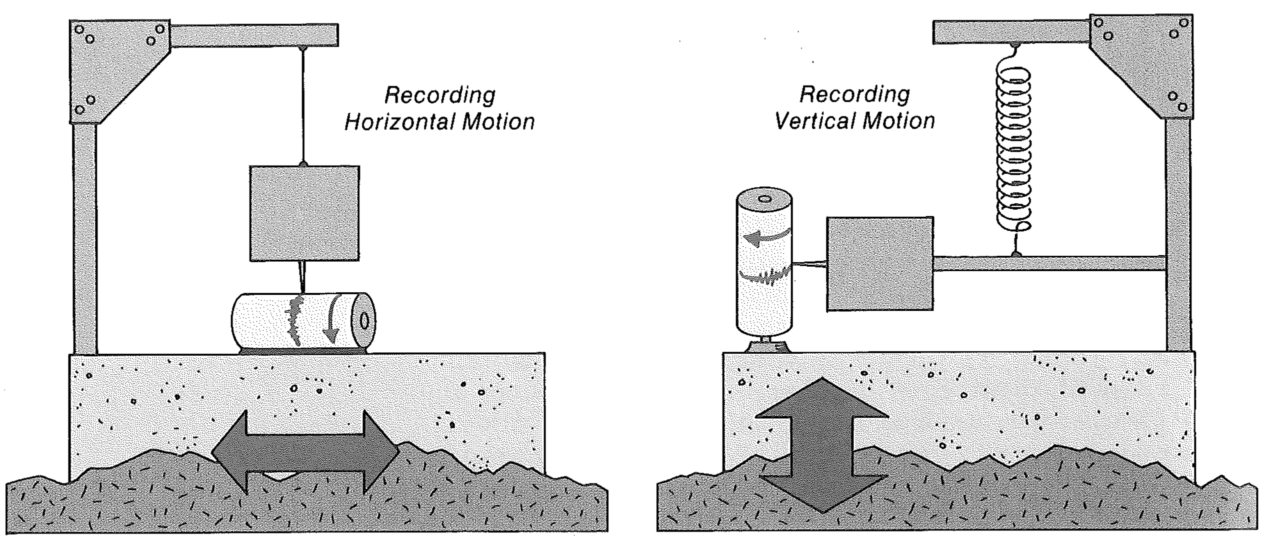
The instrument that detects and records earthquake waves is called a **seismograph.** Because there are different directions of motion produced by an earthquake—back and forth (horizontal) and up and down (vertical)—there are different kinds of seismographs. Some record horizontal motions and others record vertical motions. The way in which each works is simple.

A heavy weight is attached to a base anchored in bedrock. The weight stays almost perfectly still (due to inertia) even when the bedrock and base are being shaken by an earthquake.

A record sheet, called a **seismogram**, is put on a drum attached to the base. The drum is turned slowly by a clock. A pen attached to the heavy weight rests its point on the drum. As long as the bedrock is quiet, the pen makes a straight line on the turning drum. When the bedrock shakes, the drum shakes slightly. However, the pen does not shake because it is attached to the heavy weight. The result is a zigzag trace that shows an earthquake is taking place.

Since *P* waves travel faster than *S* or *L* waves, the first major zigzag made on the seismogram marks the arrival of the *P* wave at the seismograph station. The distance the pen departs from the center tracing is related to the amount of energy released by the earthquake. The larger the zigzag, the bigger the earthquake. The slower *S* wave arrives next, producing a different pattern. The *L* waves arrive last.

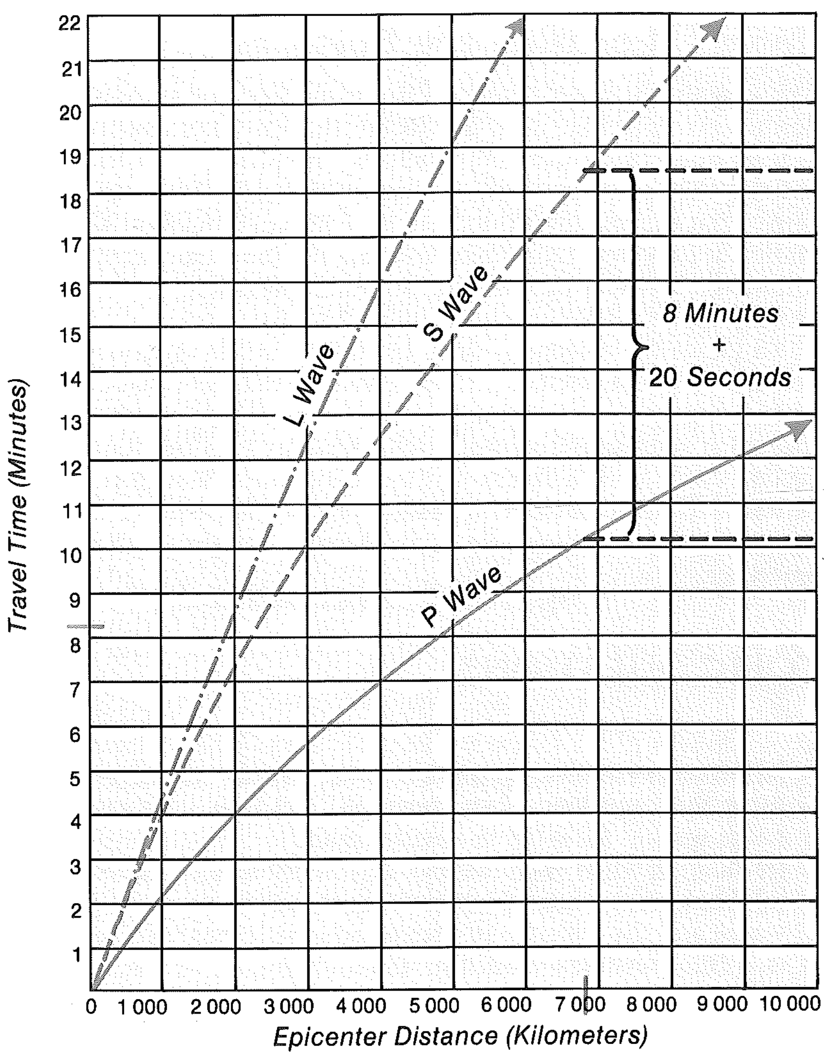
Seismographs are built differently to record different earthquakes. Some are designed to measure small earthquakes that occur near the seismograph station, while others may record moderate earthquakes located thousands of kilometers away.



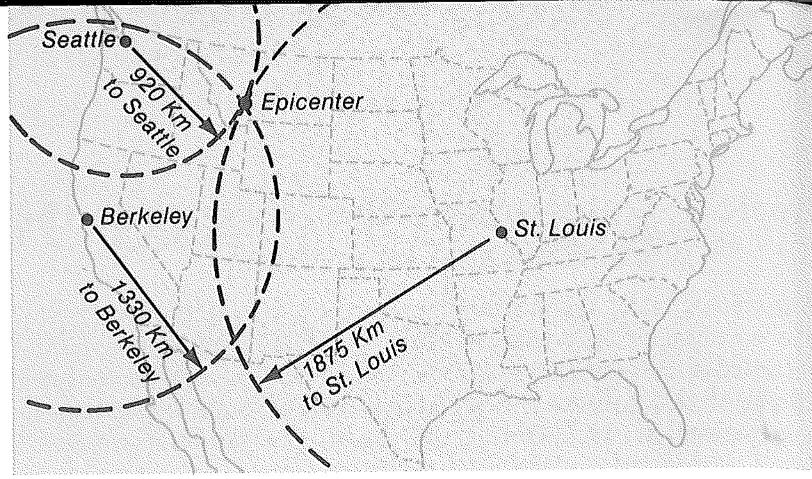
Topic 6 Determining the Distance to the Earthquake Epicenter

The tracing made by a seismograph can be used to tell how far away the earthquake epicenter is from the seismograph station that recorded the tracing. Since *P* waves travel faster than *S* waves (Topic 4), the *P* waves made by the earthquake always arrive at a seismograph station before the *S* waves. The farther the seismograph station is from the earthquake epicenter, the larger the difference is in the arrival times of the two waves. For example, the difference in arrival times for the *P* and *S* waves for an earthquake that occurs 2000 kilometers from a seismograph station is about 3 minutes 10 seconds. The difference for a station 5000 kilometers away is about 6 minutes 40 seconds.

The relationship between *P* and *S* wave travel times and epicenter distance is shown on a **time-travel graph** (Figure 15.6). If the



15.6 A time-travel graph can be used to find the distance to an earthquake. For example, if the difference between the arrival times of the *P* and *S* waves is 8 minutes 20 seconds, the earthquake occurred 6800 kilometers from the seismograph station.



15.7 A single seismograph station can only determine the distance to the epicenter. Three stations are needed to pinpoint the exact location of the epicenter.

difference in the arrival times of the two waves is known, the distance to the epicenter can be read directly from the graph. For example, suppose the time difference between the arrival of the *P* wave and the arrival of the *S* wave is 8 minutes 20 seconds. The distance from the seismograph station to the earthquake epicenter is 6800 kilometers.

Topic 7 Locating the Epicenter

Knowing the distance between a single seismograph station and an earthquake epicenter does not locate the epicenter. Instead, distances from three different stations are needed. For example, assume that a seismograph station at St. Louis, Missouri, determines that the epicenter is located 1875 kilometers away. A second station at Berkeley, California, find that the same epicenter is 1330 kilometers away. A third station at Seattle, Washington, finds that the distance to the epicenter is only 920 kilometers.

To locate the epicenter, three circles are drawn on a map. The center of the first circle is St. Louis, and the radius of that circle is 1875 kilometers. You know that the earthquake's epicenter was located at some point on that circle. Berkeley is at the center of a second circle with a radius of 1330 kilometers. Seattle is at the center of the third circle with a radius of 920 kilometers. The point where all three circles meet is the location of the earthquake's epicenter.

TOPIC QUESTIONS

Each topic question refers to the topic of the same number.

5. **(a)** What does a seismograph detect and record? **(b)** Why is there more than one kind of seismograph? **(c)** How does a seismograph work? **(d)** What is a seismogram?
6. **(a)** What kind of wave arrives at a seismograph station first? **(b)** What is the relationship between the arrival times of *P* and *S* waves and the distance to the earthquake epicenter? **(c)** What is a time-travel graph used to determine?
7. **(a)** How many seismograph stations are needed to locate an epicenter? **(b)** How is the epicenter located?